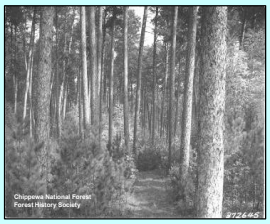
Ecological Silviculture for Great Lakes Mixed-Pine Woodlands Restoring and Sustaining Ecosystems



What, where, and why
-Foundational principles..review
-Ecological silviculture for mixed-pine
-Is ecological silviculture also adaptation silviculture?

Palik et al. 2020. Ecological silviculture. Waveland Press
Palik and D'Amato. 2023. *Ecological silvicultural systems.* Wiley Press

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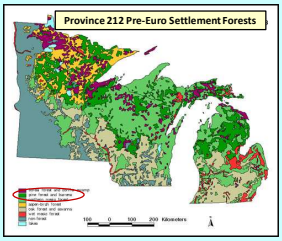
What and Where | Laurentian-Acadian Northern Pine-(Oak) Woodlands | ....aka Red Pine



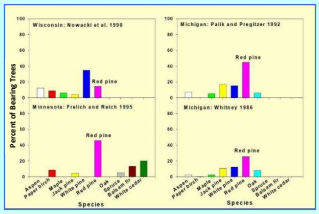
1.4 million ha pine

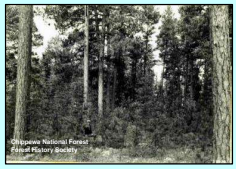
What do we know about this ecosystem?

2

Red pine forests were mixed-species ecosystems

Minnesota: Northern dry-mesic mixed woodland (FDn33a): red pine, eastern white pine, jack pine, trembling aspen, paper birch, balsam fir, red maple, big-tooth aspen, black spruce, northern red oak, white spruce





All three native pines are in this photo

Not Just Red Pine!

3

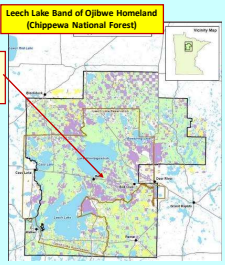
Mixed-severity fire regimes, including less-than-stand-replacing fire
(Bergman 1924, Shirely 1932, Eyre and Zehngraff 1948)

Fire intervals: 1-40 years
Mean fire interval: 6.6 yrs
Range reflects variation in Indigenous use spatially and temporally

Stambaugh et al. 2021. Forest Ecology and Management

Similar estimates in WI and MI

Leech Lake Band of Ojibwe Homeland
(Chippewa National Forest)



Not always (or often) stand-replacing fire

4

Mixed-pine ecosystems were often woodlands with variably open canopy

MN Native Plant Communities (with red pine):
Northern Dry-Mesic Mixed Woodland (FDn33a) 50-75%
Northern Dry-Sand Pine Woodland (FDn12b) 50-75%
Northern Dry-Bedrock Pine (Oak) Woodland (FDn22b,d) 25-50%
Northern Poor Dry-Mesic Mixed Woodland (FDn32a,b) 25-100%

Not always closed canopy, high density forests

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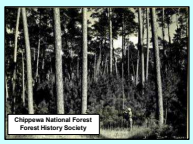
Mixed-pine ecosystems had complex age structures, including old trees

Overstory present during regeneration events (Bergman 1924, Shirely 1932, Eyre and Zehngraff 1948)



"Nature's own group selection: red pine reproduction was generally shaded out within a few years except in openings caused by tree mortality."

"After patchy disturbance in red pine stand (140 years old), red pine reproduction established in groups."

"Large old pines and red pine cohort regeneration."

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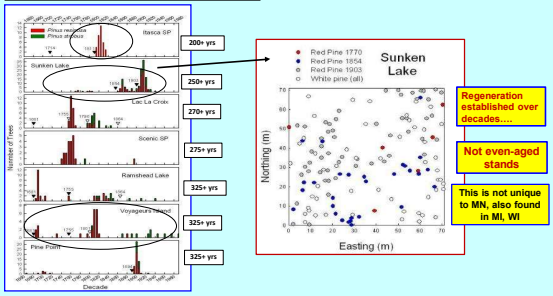
Multi-cohort to broadly single-cohort age structures

Fraver & Palik. 2012. J. of Veg. Sci.



Regeneration established over decades….

Not even-aged stands

This is not unique to MN, also found in MI, WI

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Mixed-pine ecosystems had complex structures

Fraver & Palik. 2012. J. Veg. Sci.	Trees >40 cm	Snags >40 cm	Uprootings	DWD
Site	dbh/ha	dbh/ha	No./ha	m^3/ha
Itasca State Park	130	10	24	61.6
Sunken Lake	104	2	15	74.5
Lac La Croix	112	24	16	127.6
Scenic State Park	92	6	30	82.4
Ramshead Lake	114	22	2	120.4
Voyageurs Island	80	54	24	157.8
Pine Point	62	20	22	75.5

Not just about old-growth…these are long-lived features that will be present in younger stands that have multi-cohort (complex) structure

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What do we know about this ecosystem?

To summarize:

-Mixed-severity (including less than stand-replacing) fire regime
-Mixed-species
-Woodlands with variable canopy cover
-Complex and variable age structures
-Old trees and young cohorts
-Large live and dead trees

Red Pine (mixed-pine) forests now

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Red Pine in the Lake States

-Reduced in area: from 1.4 million ha to ~250,000 ha
-Overly red pine dominated; high stocking (favor A line)
-Generally shorter rotations (60-90-120 yrs)
-Fire excluded, often (not always)
-Spatially homogeneous
-Dense woody shrubs (hazel)
-Plantations (76% in MN,MI,WI)
-High economic value
-Timber-focused silviculture

~300,000-450,000 cords harvested annually
-Sawtimber, utility poles, cabin logs

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Red Pine Managed for Timber (SSS):
-Structurally simple
-Spatially simple (homogeneous)
-Species simple (tree species poor)

Nothing wrong with this model, unless your objectives include more than timber as the priority

Sawtimber, utility poles

Year	Activity
0	Clearcut harvest
1	Site preparation
2	Plant in spring
2-4	Browsing control
4-5	Competition control
30	First thinning
45	Potential second thinning
60	Potential third thinning
50-90	Final harvest

But, you think, timber stands are younger stands…of course they display SSS?

Past belief: this somehow emulated natural dynamics…?

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Yes but…*They are too simple!*
-pine ecosystems have more complexity/diversity at all developmental stages
-management truncates development, so little structure is carried into new stand

Naturally, young stands (cohorts) might develop in a context like this:

How to reduce SSS in all stages:
Ecological Silvicultural for Mixed-Pine

Older managed stands have simple structure:

Fraver & Palik. 2012. J. Veg. Sci.

Site	Trees >40 cm dbh/ha	Snags >40 cm dbh/ha	Uprootings No./ha	DWD m^3/ha
Old forest	130	10	24	61.6
Managed	8	1	--	32.6

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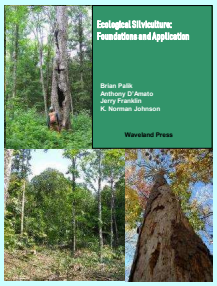

Starts with: Foundational Principles

Continuity, Complexity/Diversity, Timing, Context

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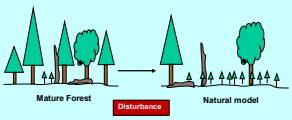
Continuity of structure, function, and biota between pre- and post-disturbance ecosystems….*biological legacies, retention harvesting*



Post-natural disturbance pine stands

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Complexity/Diversity Structural complexity, heterogeneity, species diversity in established stands

Variable density thinning, decadence creation, enrichment planting

-Canopy heterogeneity
-Declining and dead trees
-Big trees, complex crowns
-Resource/microclimate variation
-Specialized habitat
-More than one tree species

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Timing Recovery/development of complex/heterogeneous structure…*recovery vs rotation*

Timing: allowing at least some trees to live out their natural life-span

Silvicultural interventions (e.g. thinning) timed by ecological ques vs economics/growth metrics

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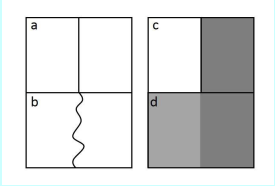
Landscape (larger-scale) Context

Stand-scale dynamics in a larger scale context
Edge/patch structure, cumulative effects, connectivity



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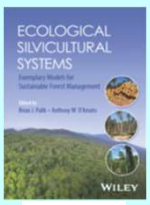
What to do with foundational principles? Incorporate them into a silvicultural system

Ecological silvicultural system: the long-term sequence of treatments for restoring and sustaining composition and complex structure of forests; informed by natural disturbance and development; incorporates foundational principles

Systems named after the natural disturbance regime…*disturbance archetype:*

Archetype 4: *characterized by disturbances of varying severity, ranging from infrequent, near stand-replacing, to heavy, but less than stand-replacing*

-Sustained dominance by intolerant species
-Mixed-species
-Extended pre-forest, young and mature stages
-Long-lived trees
-Complex age structures
-Structurally complex and heterogeneous



Palik & D'Amato (2023)

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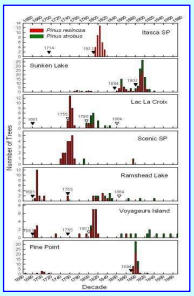
Great Lakes Mixed-Pine Woodlands

- Sustained dominance by intolerant Red Pine
- Inclusions of 10-11 other tree species
- Extended pre-forest, young and mature stages
- Long-lived red and white pines
- Complex age structures
- Structurally complex and heterogeneous
- Frequent fire…e.g., 6.6 yr mean return interval, but of varying severity



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Ecological Silvicultural System: Great Lakes Mixed-Pine Ecosystem

Palik et al. (2020)
Palik & D'Amato (2023)

Developmental Stage/Event	Duration (yrs)	Example Activities
Disturbance and Legacy Creation	0	Variable retention harvest; deadwood creation
Preforest	1 to 5+ (20+)	Site preparation including fire; competition control; regeneration
Young Forest (early)	5 to 30	Regeneration; browse control; release
Young Forest (later)	30 to 70	Variable density thinning (VDT))
Mature Forest	70 to 150	VDT; regeneration in VDT gaps; deadwood creation; competition control; Rx fire
		Variable retention harvest
Old Forest	+150	Decadence/deadwood creation; VDT; regeneration in openings; competition control-Rx fire; VRH?

Continuity
Complexity/ Diversity
Timing
Continuity
Timing

Less-than stand replacing w/ development of old=forest structures

Old-forest development

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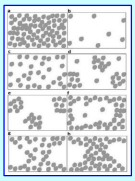
Stage	Yrs	Actions	Outcomes
Disturbance/ Legacy Creation	0	Variable retention harvest Deliberate creation and/or retention of dead wood Rx fire	Continuity of structure; maintain functionality; increase growing space; initiate pre-forest stage

Palik & D'Amato 2019. Ecological Processes

VRH: Variable in Practice:
Large group to irregular shelterwood



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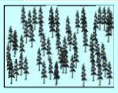
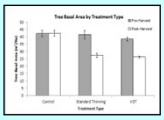
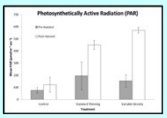
Stage	Duration (yrs)	Actions	Outcomes
Young Forest	30-70	Variable density thinning (VDT) VDT gaps: site preparation, competition control, regeneration Rx fire	Increase growth of trees; enhance complexity/heterogeneity; enrich tree species



Variable Density Thinning:

1) Accelerates the development of spatial heterogeneity
2) Shortens time required to reach complexity characteristic of mature forest





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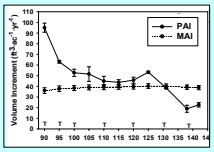
Stage	Yrs	Actions	Outcomes
Mature Forest	70-150	VDT; crop tree release	Increase growth of trees; accelerate development of complex structures; establish a new cohort
		VDT gaps: site preparation, competition control; regeneration	
		Variable retention harvest	
		Rx fire	

D'Amato et al. 2010. CJFR
Montgomery et al. 2013. FEM.
Palik and Kastendick. 2023. FEM.



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Stage	Duration (yrs)	Actions	Outcomes
Old Forest	150+	Do nothing? Decadence/deadwood creation Rx fire or surrogate to reduce aggressive shrubs and fire-sensitive hardwoods VDT in dense stands	Enhance complexity and heterogeneity, enrich species, restore structure *Restoration of old-forest stage stands*

Principle 4: Landscape Context:
-little old or mature pine woodland
-76% in plantations

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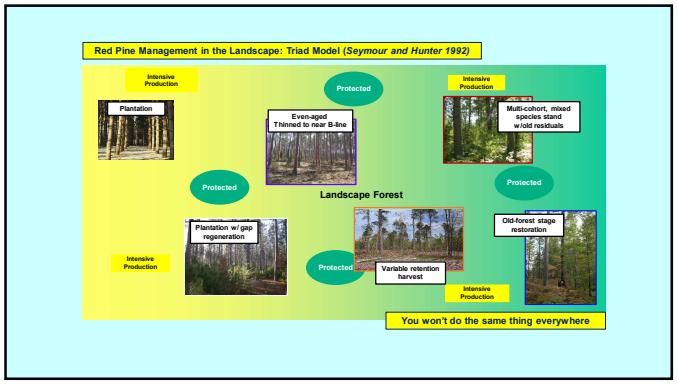

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Does ecological silviculture look too much to the past…restoring to conditions that are no longer relevant?

-Invasive species
-Climate change

Ecological silviculture is designed to respond to these drivers
Ecological Silviculture can be Adaptation Silviculture…..

D'Amato & Palik. 2021. CJFR.

Red pine timber-focused silviculture	*Mixed-pine ecological silviculture*
-Reduction in tree species richness -Simplified age and size structure -Higher stocking (density, BA) -Productivity/economic timing *Limits options in the face of uncertainty*	-Sustain/restore tree species richness -Allow/treat for development of complex age and size structure -Ecosystem-appropriate stocking and timing *Enhanced adaptive capacity & options*

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Resistance: Thinning in red pine

Resilience: VDT_VRH; planting native adapted species

Transition: Irregular shelterwood; planting adapted native & novel species

Thinning to lower stocking..is ecological (natural model) and adaptive (increases drought resistance)

Restoring complex structure and diverse tree species..is ecological (natural model) and adaptive (diverse portfolio)

Moving species and genotypes..can be ecological (overcoming migration barriers) and adaptive (climate smart)

Bottero et al. J. Appl. Eco. 2017

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Ecological Silviculture: Great Lakes Mixed Pine Woodlands

-Silvicultural system is based on a natural model for the ecosystem (*ecological silvicultural system*)
An explicit goal is to reduce the disparity between the managed and natural stands
-Silviculture is ecosystem centric…restoring/sustaining ecosystem structure and function is the priority
Does not exclude timber as an objective….dog (ecosystem) waging the tail (timber) silviculture
-Consider the landscape…triad model…ES for red pine won't be the same everywhere or used by everyone
-Ecological silviculture for mixed-pine is responsive to changing drivers
More responsive to the evolving needs of stewards and stakeholders
-Ecological silviculture for pine woodlands can be adaptation silviculture

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